

Comparison of various Image Registration Techniques with the Proposed Hybrid System

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Abstract—Image Registration is termed as the method to transform different forms of image data into one coordinate system. Registration is a important part in image processing which is used for matching the pictures which are obtained at different time intervals or from various sensors. A broad range of registration techniques have been developed for the various types of image data. These techniques are independently studied for many applications resulting in the large body of result. Vision is the most advanced of human sensors, so naturally images play one of the most important roles in human perception. Image registration is one of the branches encompassed by the diverse field of digital image processing. Due to its importance in many application areas as well as since its nature is complicated; image registration is now the topic of much recent research. Registration algorithms tend to compute transformations to set correspondence between the two images. In this paper the survey is done on various image registration techniques. Also the different techniques are compared with the proposed system of the project.

Index Terms— Image Registration, Area-based Method, Feature-based Method, Spatial Transformation Domain, Discrete Cosine Transform (DCT), Affine Transformation, Scale Invariant Fourier Transform (SIFT)

I. INTRODUCTION

Registration is an important part in image processing and is used to match two or more image data. As given in the abstract the term Image Registration is the process to transform the different sets of image data into one co-ordinate system. The image which is first registered is called as reference image and the one which has to be matched to the reference image is said to be sensed image [9].

In image registration first the feature set is found, then similarity measure is indicated, and then depending on previous two, search set and search strategy is defined[9]. Feature term is made to indicate the characteristics such as value of the color intensities of the image. These features will be extracted from the images and they will be compared in the registration process of the images. The similarity measure (SM) which is a function will returns a scalar value. These values provide an indication of the similarities between two features. The values so obtained of the SM will be used to obtain transformations for aligning the images [9]. In this paper the various registration techniques are mentioned. Also it is mentioned about the comparison of many image registration methods namely area-based method, registration

in spatial domain, in transformation domain, and in spatial-transformation domain that is feature-based method.

Section 2 gives the review of various papers. Section 3 gives the image registration algorithms. Now in Section 4 the frequency domain method is mentioned. Section 5 gives the various comparison methods. Section 6 gives the Spatial-Domain part. Section 7 gives the Transformation Domain part. Section 8 gives the Spatial-Transformation Domain Method. Section 9 gives the comparison of various Image Registration Methods. Section 10 concludes the above paper.

II. REVIEW OF VARIOUS PAPERS

The image registration algorithms can be in area-based method and feature-based method. In feature-based part the image registration is done in Spatial Domain, in Transformation Domain, also in Spatial-Transformation Domain. In area-based Method Ruhina B. Karani et al [2] suggests that a small pixel window in sensed image will be statistically compared with same size windows in the reference image. The methods used here are to find cross correlation coefficient and also least square match. The matched window centers will be taken as control points. These points can be used to solve for matching functions parameters between the two that is reference image and the sensed image.

In Spatial Domain Ruhina B. Karani et al [2] states that Discrete Cosine Transform is a separable linear transformation. It means that the two dimensional DCT transform is same as a one-dimensional transform obtained along a single dimension and it will be followed by one dimensional transform in another dimension.

In Transformation Domain Jimmy Singla et al [5] states the procedure of affine transformation for image registration. He uses the Harris corner detector for finding the point features obtained by the first order image gradient. Then he uses the correlation techniques to find the corresponding matching part between the two images. Then the transformation parameters such as various affine parameters are found out. Here three steps such as transformation, rotation and scaling is done to the sensed image which has to be brought in the co-ordinate system of the database image.

The Spatial-Transformation Domain which is the proposed system of the project uses the hybrid of the area and feature-based method. Segmentation is the first step and is used for dividing an image into many different equiprobable parts so that its further analysis will result in higher level

representation of an image pixels. Image segmentation has been classified into a number of methods and they are applied to both monochrome or color images [4]. Shamik Sural et al [1] used the feature based method for image segmentation. In this he made analysis of the HSV color space. Now next to this the extraction of features is done with the last step of implementing the K-means algorithm.

Next the image features descriptor has to be found. Hernani Goncalves et al [4] used SIFT descriptors to find local image descriptors.

The SIFT approach allows to extract number of distinctive nonvariant image features. These are used to form matching between the images. David Lowe et al [6] states that a SIFT descriptor is a 3-D histogram. It is of gradient orientation and location. This gradient locations are quantized into a 4×4 location grid.

Jimmy Singla et al [5] states that the affine transformation is formed from transformation rotation and scaling. Mehfuza Holia et al [7] states that the co-rrrelation coefficient is the evaluation parameters used to find the matching of two or more images. The image is rotated in steps. At one particular rotation the maximum correlation coefficient is obtained. Different scales will also be applied to the images. At one particular scale maximum co-relation coefficient is obtained. This rotation and scaling at which the maximum co-relation coefficient is obtained is considered as properly registered image.

III. IMAGE REGISTRATION ALGORITHMS

The image registration algorithm is broadly classified depending on whether it is an area-based method or feature-based method [8]. There are several algorithms such as:

- Algorithms that can operate in frequency domain eg. Fast Fourier Transform Technique.
- Algorithm that directly use image pixel values eg. Wavelets- Modulus Maxima Method.
- Algorithms which can use lower level features eg edges or corners eg (Feature-based Methods)

A. Area-based Methods

In this method one of the main steps is the feature matching step rather than their detection. So no features will be detected in these methods and so the first step of image registration i.e. feature detection is not required. For this method, the algorithm finds the image structure with respect to correlation metrics or Fourier properties and another method of structural analysis.

B. Feature-based Methods

This method is based on the extraction of important distinctive and salient structures which are features in the images. Various important regions, points or lines must be distinct. They have to be spread over the entire image and properly detectable in both images. The above features must be stable in time so that they will stay at fixed positions during the entire experiment.

1. Region features: They are the projections formed from

general high contrast closed-boundary regions with appropriate scale and size. Here we can represent the regions by the centers of gravity. The parts in above regions will be nonvariant with respect to skewing, rotation, scaling. They are stable under noise generated randomly. Region features are detected and found by using segmentation methods.

2. Line features: We can represent them as general line segments, elongated form of anatomic structure or object contours. They are used in medical imaging. Edge detect methods in standard forms can be used for their detection.
3. Point features: We can represent them as the methods suitable for working along with line intersections, centroids of water regions. They are obtained by detecting by use of the Gabor wavelets. Feature-based methods is suggested if the images are said to have proper distinct and easily detectable objects.

C. Advantages of Hybrid Area and Feature-based Method

It has low memory requirements and also increased Computational Efficiency. It has good localization in frequency, time and spatial domain. All the features are nonvariant to rotation and scaling. The system has higher flexibility and better identification of data and so it has higher compression ratio [4].

Feature-based method is further divide into:

- Frequency Domain Method
- Spatial Domain Method
- Transformation Domain Method
- Hybridization of Spatial and Transformation Domain i.e. Spatial-Transformation Domain Method.

IV. FREQUENCY DOMAIN METHODS

Some algorithms use the frequency domain properties which directly determine shifts occurred between two images. We can produce a third image which contains a single peak by applying the phase correlation method to a pair of overlapping images. The position of this peak must correspond to the relative translation occurred between the two images. The phase correlation method is not affected by noise, clutter or occlusions. Also, the Fast Fourier Transform used by the phase correlation is used to find cross correlation coefficient between the two data images.

V COMPARISON METHODS AND PROBLEM STATEMENT

Following section deals with the various feature and area based methods which are used for comparison purpose.

VI SPATIAL-DOMAIN METHODS

Most of the methods operate in the spatial domain and they use textures, features and structures for matching criteria. In the spatial domain, images look 'normal' as the human eye might observe them. In this some of the feature matching algorithms are outcomes of past techniques used for performing manual image registration where operators are allowed to choose matching sets of control points (CPs)

between images.

A Discrete Cosine Transform

Method 1 is as shown in the Fig. 1. Method 1 is Image registration by DCT and in this first the original image is captured. Then the Edge and corner detection is applied [2], [3]. Here the threshold is set to 205 at which we get proper results. Next is it to find the displacement parameters and DCT coefficients. In this system the displacement parameters obtained are 0 for input image, 5 for DCT plane, 21 for merged DCT and 16 for overlapped and reconstituted i.e. registered image. The DCT coefficients obtained are 0, 16, 5, 21, 6, 22. In the Fig. 1 the original merged and reconstituted image is shown after overlap source and DCT image block. Then the correlation is found between the original and registered image which is 0.879982.

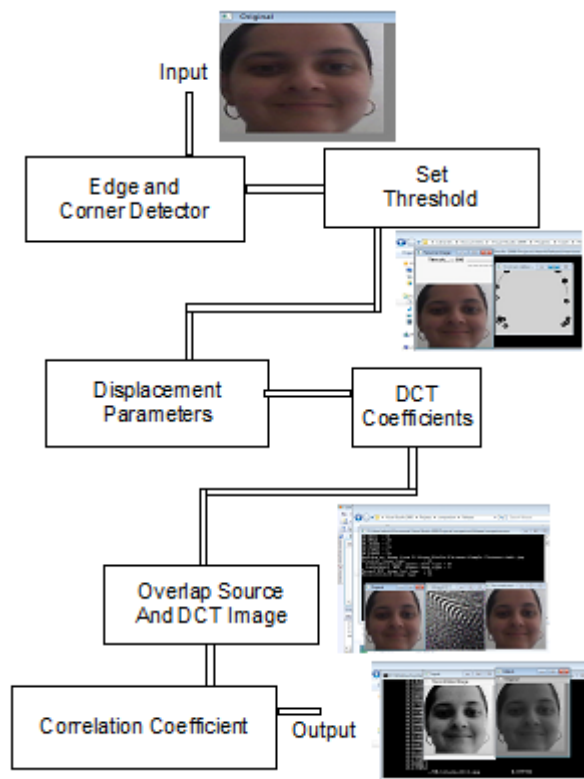


Figure 1. Method 1: Image Registration by DCT

VII. TRANSFORMATION DOMAIN

Here the Harris corner Edge detector is used for feature description [5]. After the feature matching has been obtained, then the mapping function need to be constructed. It should properly transform the sensed image to overlap it over the reference image data. Now the image registration algorithms is classified accordingly with the transformation model which is used to relate the reference image data with the target image data. This part of transformation models has linear transformations having shear, rotation, scaling, and translation.

Linear transformations are said to be global in nature.

So they will not be able to model the local deformations. Usually, the perspective components will not be useful for

data registration, and hence the linear transformation is an affine one used in this case.

The second part includes 'nonrigid' or elastic transformations. These transformations will allow for local wrapping of image features. So it provides support for local deformations. Nonrigid transformation approach has polynomial wrapping.

A Affine Transformation

The method 2 is as shown in the Fig. 2. Method 2 is by Affine Transformation and here the Harris operator is used to extract the feature points by first order image gradient [5]. Then affine transformation by rotation, scaling and translation is applied [7]. Then the feature matching algorithm is applied where the correlation technique is used for determining corresponding matching position between the two images. Correlation coefficient's absolute value of that corner pairs which is greater than the threshold is found out in the next step. This value is selected as the control points. Now affine transformation parameters are then applied. Here at 45 degree maximum coefficient of correlation is obtained, so it is considered as the angle where the image is properly registered.

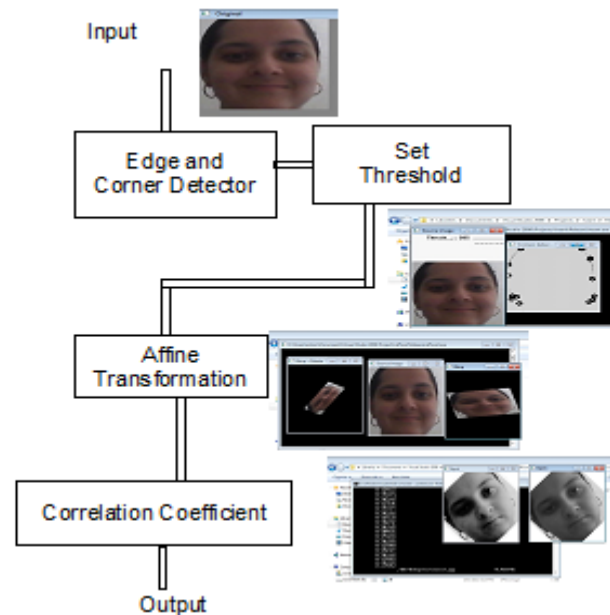


Figure 2. Method 2: Image Registration by Affine Transformation

VIII. SPATIAL-TRANSFORMATION DOMAIN METHOD

The proposed system of the project uses the hybrid of two methods that is area and feature-based in the spatial and transformation domain. The hybridization is basically done to increase the efficiency and thus overall throughput of the system and so as to reduce the computation time. It improves the compression ratio. By this method it becomes possible for good localization in both time and spatial domain. The method introduces inherent scaling. It has higher flexibility. The memory requirement is also reduced. The proposed system is as shown in the Fig. 3 [4]

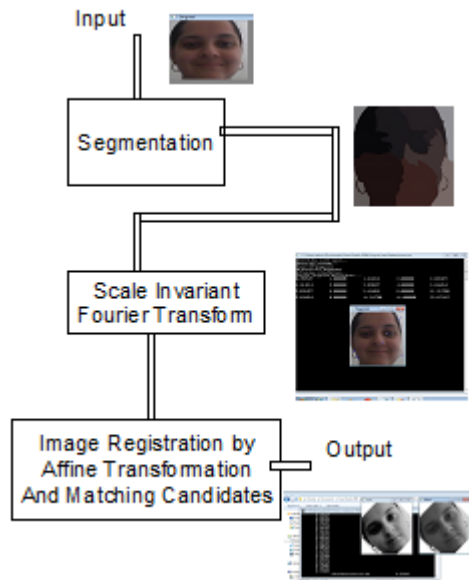


Figure 3. Method 3: Proposed System

The proposed system has three main steps namely Segmentation, Scale Invariant Fourier Transform and Image Registration. Image registration is composed of two main steps namely Obtention of Matching Candidates and use of Affine Transformation. The first two steps are feature based methods and the matching candidates is done through template matching at different rotations and scalings which is area-based method. The steps are given in details in the following sub-sections.

A Segmentation

It is nothing but a process where we partition an image into non intersecting regions in such a way that each region is homogenous and the union of two neighboring regions is not homogenous [1]. The proposed system uses Segmentation in color space such as HSV space and is done by K-means algorithm. Here first we study the properties of the HSV color space. After this the image data features are extracted based on the above study. Then apply the K-means algorithm as mentioned in [1].

The Number of pixels in the original image is 77760. The standard deviation of pixel is 48.7 and the mean is 124.9. The storage memory is 34.3Kb. The number of pixels in the segmented image is 603136. Its standard deviation is 80.5 and mean is 96.9. The result shown in the figure 3 is divided into 10 clusters. The required memory is 22Kb. Thus the proposed system has very low memory requirement. And hence the computational efficiency is increased and the overall throughput is also increased.

B. SIFT

The most powerful approaches for obtaining the local descriptors of an image data is SIFT. It transforms image data into scale-invariant co-ordinates which is relative to local features and have the major stages as Scale-Space Extrema Detection as its first stage, and Keypoint Localization as second stage. Then the next step is orientation assignment and last step is Keypoint Descriptor [6].

The first stage of computation will search over all scales and image locations that can be assigned repeatedly under different parts of the same object. To detect locations that are non variant to scale change of an image is possible by searching over all the stable features at all possible scales by using a continuous function of scale known as scale space which is Gaussian Function and the smoothed image is obtained from convolution of variable scale Gaussian with the input image. Next part in this step is to find the difference of Gaussian Function where we can find the local maxima and minima. Here each sample point is compared to its eight neighbors in the scale in the current image and nine neighbors in the scale above and below image. Then if that sample point is larger or smaller than all of the neighbors then only that keypoint is selected as local maxima or minima. Thus all the keypoints generated will not be accepted but the first criteria of rejecting the keypoints is that only local maxima and minima will be accepted and other keypoints will be rejected. Once the maxima and minima are found then we have to check the function value at the extremum which is useful for rejecting the low contrast keypoints. Next part is to eliminate the edge responses by detecting the ratio of principal of curvature. This ration is obtained from eigen values. These individual eigen values are not required but the sum and product of eigen values is required, which is obtained from trace and determinant of 2×2 Hessian matrix [6].

Once the keypoints is selected after rejection of the few by above description then we have to fit that keypoints to image locations that are non variant to scale changes.

Then the consistent orientation must be given to each keypoint selected so that the descriptor can be represented relative to this orientation and hence achieve non variance to any scale or rotation change of the image. It is obtained by finding the orientation histogram and then the peak points of that histogram is assigned with one orientation and any other local keypoint which is within 80 percent of that peak point is also assigned with the same orientation [6].

The descriptor obtained by SIFT is more distinct and is nonvariant to variations such as change in illumination or even to changes in 3D viewpoint. One method to find the SIFT descriptor is sampling of the local intensities of the images near the keypoint by the use of appropriate scale, and then to match these by using normalized correlation measure. Here instead of using Harris corner edge detector, SIFT descriptor is used.

C. Image registration

In this two steps are involved

1. Obtention of Matching Candidates

Template Matching is a technique used for obtention of matching candidates. It is used to find areas in an image that can be matched to template of an image. Here we are normalizing the output of the matching part. As its first step it will load an image [6]. Then we can perform template matching. Here a window of size $m \times n$ in the reference image is matched with the template of same size in the sensed image.

The template selected in the target image should represent highly detailed and unique regions. For template to be highly detailed it should contain a large number of high gradient edges. This is achieved by computing the sum of gradient magnitudes in the templates. If both are having similarities in their intensities then the two images are said to match with each other. These similarity measure taken here is cross correlation coefficient. The correlation coefficient lies in the range of -1 to +1. If the value is +1 then it indicates that there is maximum relation between the intensities in the two images and so the image is properly registered. Next we have to localize the location that have the huge matching probability.

2. Affine Transformation

It is a 2D affine transform which performs a linear mapping from 2D co-ordinates to other 2D co-ordinates and preserves the straightness of lines and parallelness of lines[5]. Affine transformations can be constructed using the sequence of scales, translation, rotations, and shears.

In the proposed system segmentation and SIFT descriptors are feature-based methods and the last step is area-based method.

Once the segmentation and SIFT is done then by template matching and using different scales and rotations of the image we compare that image with the database image and use the cross-correlation coefficient as evaluation parameter to say that the matching is proper or not. If the value of cross-correlation coefficient is coming maximum then image is properly registered. This is achieved by the proposed system at 45 degree rotation.

IX. RESULTS AND DISCUSSION

The results obtained are shown in the figure 3. Here the problem of corner clustering is avoided by use of SIFT for finding the local descriptor. The computational memory is minimized by segmentation as described in segmentation. Thus the overall throughput is increased. The results are compared in the next section.

X. COMPARISON OF VARIOUS IMAGE REGISTRATION METHODS

During the process of image registration, the main problem such as the clustering of the corner can occur. It will result in increasing the false matching positions eg. to match the feature point. This problem is overcome by SIFT descriptor and template matching step.

Table 1 shows the comparison of various methods.

TABLE I. COMPARISON OF IMAGE REGISTRATION METHODS

Desc.	Method		
	Area-based	Feature-based	Hybrid
Multi Modal Image	Low	Low	Low
Robust to Noise	High	Medium	Highest
Efficiency	Low	Medium	High
Accuracy	High	High	Highest
Correlation Coefficient	High	Low	Highest

In table 2 first few columns are for SIFT and affine transformation where maximum correlation is obtained at 45 degree. Next column is for mismatch where correlation is least. Last column is for DCT where correlation is lower than the method 3 which shows that the proposed system given in method 3 gives maximum correlation at which image is properly registered. Figure 4 shows the graph of correlation coefficient at various rotations and it is maximum at 45 degree rotation.

TABLE II. CORRELATION COEFFICIENT OF THE IMAGES FOR DCT AND AFFINE TRANSFORMATION AT DIFFERENT ROTATION AND SCALING

Number	Rotated Angles and Scaling	Co-relation Coefficient
1	20	0.948578
2	30	0.953339
3	45	0.956845
4	90	0.896499
5	180	0.896489
6	0.5	0.937573
7	0.6	0.937579
8	0.8	0.947494
9	1.3	0.954100
10	Mismatch	0.439905
11	By DCT	0.879982

A Advantages of Affine transformation using co-relation over Discrete Cosine Transform

1. No need to divide the input coding into non overlapping 2-D blocks, it has higher compression ratios, and so avoids blocking artifacts.
2. Allows good localization both in time and spatial frequency domain.
3. Transformation of the whole image introduces inherent scaling.
4. Better identification of which data is relevant to human perception i.e. we get a higher compression ratio.
5. Higher flexibility, i.e. affine function can be freely chosen.

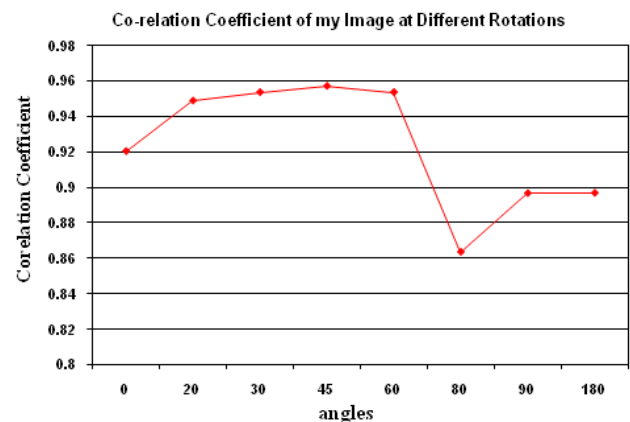


Figure 4. Correlation Coefficient versus different angles

CONCLUSIONS

Here the various methods of image registration are discussed. In the method 1 Harris corner edge detector is used for feature description. Then DCT is applied for image registration. In method 2 Harris corner edge detector is used for feature description and affine transformation is used for image registration. The proposed system is given in the method 3. Here SIFT is used for feature description and affine transformation is used for image registration. The problem of corner clustering is avoided by method 3. By combination of SIFT and template matching maximum correlation coefficient is obtained than the other methods which is shown in the table 2.

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